993-40 Characteristics of the Atrial Signal-averaged Electrocardiograms in Patients with Sick Sinus Syndrome — the Presence of "Atrial Early Potential"

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In sick sinus syndrome (SSS), pathophysiological abnormalities have been shown not only in the sinus node but also in the atrial muscle, especially of the perinodal portion. To investigate whether the electrophysiological abnormalities of atrial muscle in SSS would induce the characteristic P wave-pattern, especially in the initial portion of the P wave, we studied 37 patients with SSS and 67 age-comparable control patients, using the P wave-triggered signal-averaged electrocardiography. Sixteen of 37 SSS patients had paroxysmal atrial fibrillation (Paf). Signal-averaged electrocardiograms were recorded with a band-pass filter of 40–300 Hz and signals of 200 beats or more were averaged with the P wave-triggering technique. The P wave complexes of the three bipolar leads were combined into a spatial magnitude, and then the root mean square voltage for the initial 30 ms (EP30) and the last 20 ms (LP20) of filtered P wave were measured. The duration (Ad) and root mean square voltage (RMS) of the total filtered P wave were also measured.

Results:

	SSS with Paf	SSS without Paf	Control
EP30(μV)	2.55 ± 1.17*	2.16 ± 0.98*	3.93 ± 1.23
LP20(μV)	1.98 ± 0.40#†	2.79 ± 1.04	3.35 ± 1.76
Ad (ms)	145.8 ± 16.1*†	131.2 ± 14.1$	123.7 ± 11.7
RMS(μV)	6.20 ± 0.41	5.82 ± 0.82	6.20 ± 1.47

*$p < 0.0001$, #$p < 0.005$, $$p < 0.05$ vs. Control, †$p < 0.01$ vs SSS without Paf

The amplitude of initial portion of filtered P wave was significantly lower and the duration was longer in SSS patients with/without Paf than the controls, while there was no significant difference in the amplitude of the terminal portion between SSS patients without Paf and controls. The criteria of "EP30 $\leq$ 3.0 μV and Ad > 130 ms" as defining "atrial early potential" gave a sensitivity of 76%, a specificity of 83% and a predictive accuracy of 81% for detection of patients with SSS. These results indicate that the low amplitude signals in the initial portion of filtered P wave were characteristic of SSS, so that the recognition of atrial early potential might be promising to identify patients with SSS.

993-41 Effects of Autonomic Changes on the Signal Averaged P Wave Duration

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Signal averaged P wave duration has been shown to have prognostic significance regarding the occurrence of atrial fibrillation. However, atrial fibrillation may occur in a variety of disease states with varying autonomic tone. The effects of autonomic tone on the signal averaged P wave duration were assessed in 14 normal subjects (8 males, age 28 ± 5 years) with no cardiac disease (on no medication) under the following conditions: 1) Supine rest (Base); 2) Epinephrine (Epi) infusion at 50 ng/kg/min; 3) Isoproterenol (Iso) at 2–4 μg/min; 4) Following propranolol (β) 0.2 mg/kg; 5) Following β and atropine 0.04 mg/kg (β/At). Fifteen minute recordings were made under each condition. A sinus P wave template was selected for averaging; a 99% correlation coefficient with the template was required for inclusion in the average. The P wave duration (in milliseconds) was measured manually from the vector combination of the orthogonal leads following filtering with a least square fit filter (100 ms window).

Results: Data are reported as means ± standard deviation. Epi, Iso and β/At significantly shortened the RR interval from 980 ± 138 ms at Base to 760 ± 79, 489 ± 32, and 601 ± 42 ms respectively. RR intervals during β were 921 ± 83 ms.

	Base	Epi	Iso	β	β/At
P duration	136 ± 10	148 ± 14*	106 ± 13*	153 ± 14*	136 ± 17

*$p < 0.05$ compared to baseline by ANOVA

Iso significantly shortens the P wave duration compared to baseline. In contrast, Epi and β both prolong the P wave duration.

Conclusions: The signal averaged P wave duration is a dynamic variable responding to changes in autonomic conditions. Thus, comparisons of P wave durations among different populations must account for potential differences in autonomic tone.

993-42 Detailed Analysis of Low Amplitude Signals During the PR Segment of the High Resolution Electrocardiogram

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Analysis of the continuity of low amplitude signals during the PR segment (LASPR) of the high resolution ECG may provide insight into the nature of normal and abnormal atrioventricular (AV) conduction. *Methods:* We compared LASPR in 47 patients with normal PR interval to 20 patients with first degree PR interval prolongation. The continuity of the LASPR was analyzed using the vector magnitude plot combining the contribution of cardiac signals from all vector directions (frequency range, 40–250 Hz). The absence of an isoelectric interval >10 ms without visually distinguishable spikes from noise was defined as continuous electrical activity. The duration of the P wave and PR segment and the duration ratio of the PR segment to the PR interval were calculated from the unfiltered individual XYZ leads. The root mean square (RMS) voltages of the P wave, of the PR segment, of noise, and the voltage ratio of the PR segment to noise were calculated from the filtered XYZ leads with finite impulse response filter (frequency range, 48–250 Hz). *Results:* Forty-one (87%) of the normal PR interval group and 9 (45%) of the prolonged PR group showed continuous LASPR ($p < 0.001$). The P wave and PR segment durations were shorter, the duration ratio was lower, and the PR segment RMS voltage and voltage ratio were higher in the normal PR versus prolonged PR interval group. Shown are mean ± SD from lead X.

	Normal PR	Prolonged PR	p value
P Wave Duration (ms)	99 ± 16	117 ± 20	<0.001
PR Segment Duration (ms)	55 ± 16	99 ± 22	<0.001
Duration Ratio	0.35 ± 0.8	0.44 ± 0.8	<0.001
P wave RMS (μV)	3.4 ± 1.0	2.9 ± 1.1	0.143
PR Segment RMS (μV)	2.1 ± 1.0	1.5 ± 0.8	0.022
Noise RMS (μV)	0.31 ± 0.1	0.35 ± 0.2	0.280
Voltage Ratio	7.6 ± 4.6	4.8 ± 3.3	0.016

Conclusions: Low amplitude PR segment signals during normal PR conduction are more continuous, shorter in duration and have higher RMS voltage than those during prolonged PR conduction. These data suggest that normal AV conduction is associated with rapid, uniform propagation in contiguous structures, whereas abnormal AV conduction is associated with slower, fractionated, discontinuous conduction.

993-43 Towards a Better Understanding of the Development of Atrial Fibrillation After Cardiac Surgery: Risk Factor Analysis in a Large Prospective Study

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In a recent prospective study, we had identified prolonged p-wave duration on signal-averaged (SA) ECG as a predictor of atrial fibrillation (AF) after cardiac surgery. Although several clinical characteristics have also predicted AF, the results have been inconsistent. The purpose of the present study was to examine a variety of clinical, surgical and laboratory parameters to establish accurate risk factors, and to gain insight into the mechanism, of AF in this setting. 272 consecutive patients undergoing elective cardiac surgery were enrolled, clinical data collected and pre-op p-wave SAECG recorded. Patients were observed after cardiac surgery for the development of AF. During the period of observation, 79 of the 272 patients (29%) developed AF 2.5 ± 1.7 days (range of 1–8 days) after surgery. 22 variables were analyzed and univariate predictors of AF were identified: EF < 40%, valve surgery, pre-op use of digoxin, p-wave SAECG and p-wave on SAECG > 140 msec. Prior MI, HTN, pre-op use of beta blockers, aortic cross clamp time were not predictive. Multivariate analysis demonstrated that p-wave SAECG and low EF were significant independent predictors of AF. P-wave duration on SAECG > 140 msec and EF < 40% were associated with relative risks of 3.1 and 2.8, respectively. P-wave SAECG was the most sensitive test, identifying 82% of patients who experienced AF.

Conclusion: AF continues to be a common complication after cardiac surgery. The presence of *pre-op* anatomic and electrophysiologic abnormalities promote AF, and clinical variables can be used to identify those at greatest risk.

993-44 The Ventricular Response in Atrial Fibrillation is Not Chaotic

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In nonlinear dynamics, chaos refers to a system that is aperiodic but deter-